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A simple quantitative approach to assess past, present and future dynamic behaviour and stability of tidewater glaciers

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Glaciers and ice sheet outlets that terminate in the ocean are known to respond highly non-linearly to climate change as indicated in recent rapid changes of tidewater glaciers in Alaska and Greenland. This makes interpretation of terminus changes and future predictions difficult and current numerical models are still struggling to reproduce such behaviour.

Here we propose a simple approach to quantitatively assess stability (or instability) of tidewater glacier termini and get a first order estimate of potential retreat rates. We use the flux-boundary theory for grounded calving termini of Schoof (2007) and further take into account variations in glacier width. We compare this terminus flux with the balance flux in order to assess stability and further use a simple relation to translate this flux difference into a potential retreat rate. We explore the use of such a simple approach on the examples of two currently retreating tidewater glaciers (Columbia Glacier and Hansbreen) and one palaeo ice stream in the Uummannaq area in Greenland. Although this approach is highly simplified and the absolute retreat rates have a high uncertainty, the relative variations are useful in assisting interpretation and assessment of present and near future behaviour and reconstructions of palaeo records of tidewater retreat. Crucially, this approach relies on only minimal data (bed topography and approximate surface mass balance) and is therefore widely applicable.